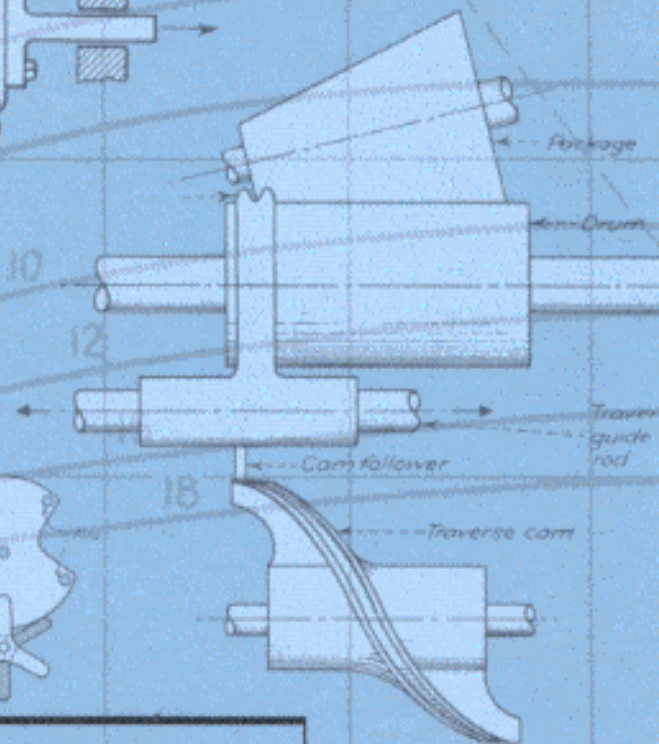
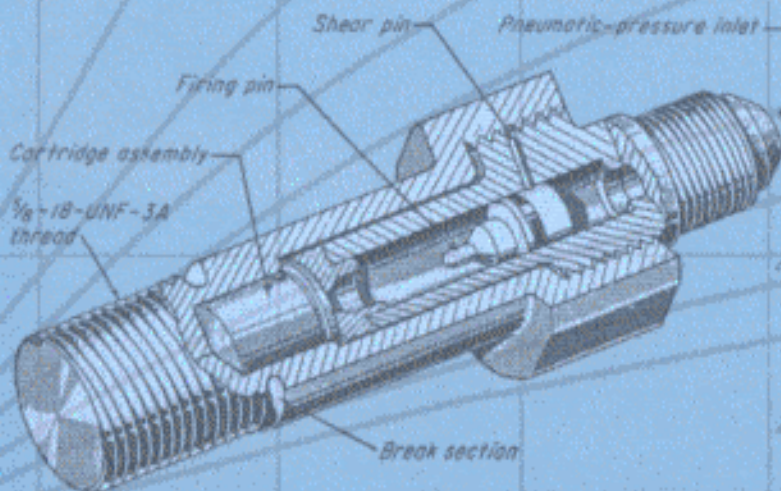
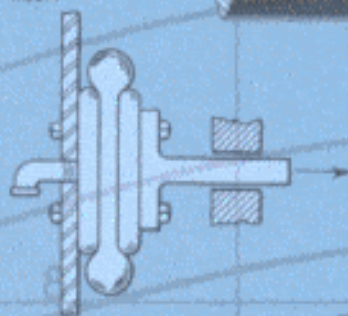
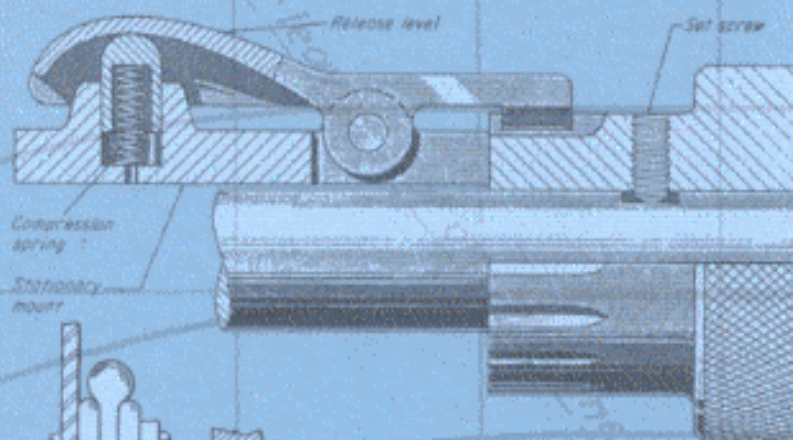
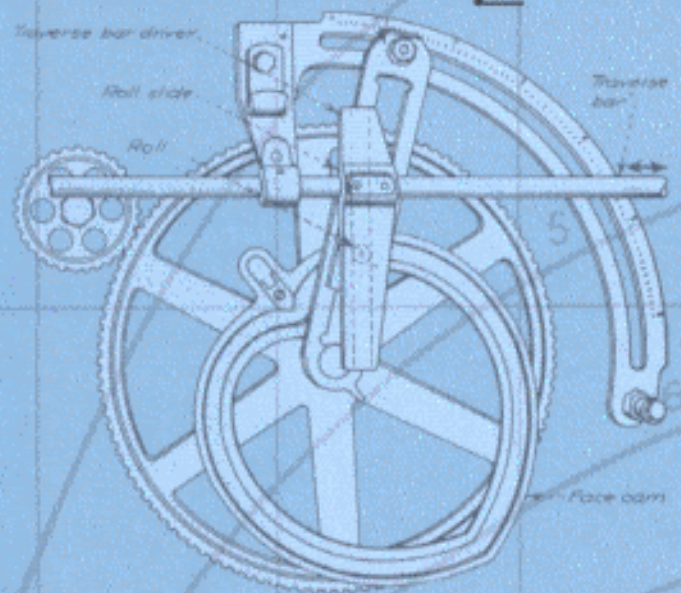


MECHANISMS and MECHANICAL DEVICES SOURCEBOOK

THIRD EDITION



Neil Sclater
Nicholas P. Chironis

Angular Displacement of the Driving Crank at a dea

CONTENTS

PREFACE	xiii
ACKNOWLEDGMENTS	xv
CHAPTER 1 MOTION CONTROL SYSTEMS	1
Motion Control Systems Overview	2
Glossary of Motion Control Terms	9
High-Speed Gearheads Improve Small Servo Performance	10
Modular Single-Axis Motion Systems	12
Mechanical Components Form Specialized Motion-Control Systems	13
Servomotors, Stepper Motors, and Actuators for Motion Control	14
Servosystem Feedback Sensors	22
Solenoids and Their Applications	29
CHAPTER 2 ROBOT MECHANISMS	33
Industrial Robots	34
FANUC Robot Specifications	38
Mechanism for Planar Manipulation With Simplified Kinematics	43
Tool-Changing Mechanism for Robot	44
Piezoelectric Motor in Robot Finger Joint	45
Six-Degree-of-Freedom Parallel Minimanipulator	46
Self-Reconfigurable, Two-Arm Manipulator With Bracing	47
Improved Roller and Gear Drives for Robots and Vehicles	48
All-Terrain Vehicle With Self-Righting and Pose Control	49
CHAPTER 3 PARTS-HANDLING MECHANISMS	51
Mechanisms That Sort, Feed, or Weigh	52
Cutting Mechanisms	56
Flipping Mechanisms	58
Vibrating Mechanism	58
Seven Basic Parts Selectors	59
Eleven Parts-Handling Mechanisms	60
Seven Automatic-Feed Mechanisms	62
Seven Linkages for Transport Mechanisms	65
Conveyor Systems for Production Machines	68
Traversing Mechanisms for Winding Machines	73
Vacuum Pickup Positions Pills	75
Machine Applies Labels from Stacks or Rollers	75
High-Speed Machines for Adhesive Applications	76
Automatic Stopping Mechanisms for Faulty Machine Operation	82
Electrical Automatic Stopping Mechanisms	88
Automatic Safety Mechanisms for Operating Machines	90
CHAPTER 4 RECIPROCATING AND GENERAL-PURPOSE MECHANISM	93
Gears and Eccentric Disk Combine in Quick Indexing	94
Timing Belts, Four-Bar Linkage Team Up for Smooth Indexing	95
Modified Ratchet Drive	96
Odd Shapes in Planetary Give Smooth Stop and Go	97
Cycloid Gear Mechanism Controls Stroke of Pump	99
Converting Rotary-to-Linear Motion	100
New Star Wheels Challenge Geneva Drives for Indexing	100

Geneva Mechanisms	103
Modified Geneva Drives	106
Indexing and Intermittent Mechanisms	108
Rotary-to-Reciprocating Motion and Dwell Mechanisms	116
Friction Devices for Intermittent Rotary Motion	122
No Teeth on These Ratchets	124
Cam-Controlled Planetary Gear System	125
CHAPTER 5 SPECIAL-PURPOSE MECHANISMS	127
Nine Different Ball Slides for Linear Motion	128
Ball-Bearing Screws Convert Rotary to Linear Motion	130
Three-Point Gear/Leadscrew Positioning	131
Unique Linkage Produces Precise Straight-Line Motion	132
Twelve Expanding and Contracting Devices	134
Five Linkages for Straight-Line Motion	136
Linkage Ratios for Straight-Line Mechanisms	138
Linkages for Other Motions	139
Five Cardan-Gear Mechanisms	140
Ten Ways to Change Straight-Line Direction	142
Nine More Ways to Change Straight-Line Direction	144
Linkages for Accelerating and Decelerating Linear Strokes	146
Linkages for Multiplying Short Motions	148
Parallel-Link Mechanisms	150
Stroke Multiplier	150
Force and Stroke Multipliers	152
Stroke-Amplifying Mechanisms	154
Adjustable-Stroke Mechanisms	155
Adjustable-Output Mechanisms	156
Reversing Mechanisms	158
Computing Mechanisms	159
Eighteen Variations of Differential Linkage	163
Space Mechanisms	165
Seven Popular Types of Three-Dimensional Drives	167
Inchworm Actuator	172
CHAPTER 6 SPRING, BELLOW, FLEXURE, SCREW, AND BALL DEVICES	173
Flat Springs in Mechanisms	174
Pop-Up Springs Get New Backbone	176
Twelve Ways to Put Springs to Work	177
Overriding Spring Mechanisms for Low-Torque Drives	179
Spring Motors and Typical Associated Mechanisms	181
Flexures Accurately Support Pivoting Mechanisms and Instruments	183
Taut Bands and Leadscrew Provide Accurate Rotary Motion	185
Air Spring Mechanisms	186
Obtaining Variable Rates from Springs	188
Belleville Springs	189
Spring-Type Linkage for Vibration Control	190
Twenty Screw Devices	191
Ten Ways to Employ Screw Mechanisms	194
Seven Special Screw Arrangements	195
Fourteen Adjusting Devices	196
Linear Roller Bearings Are Suited for High-Load, Heavy-Duty Tasks	197
CHAPTER 7 CAM, TOGGLE, CHAIN, AND BELT MECHANISMS	199
Cam Basics	200
Cam-Curve Generating Mechanisms	201

Fifteen Ideas for Cam Mechanisms	207
Special-Function Cams	209
Cam Drives for Machine Tools	210
Toggle Linkage Applications in Different Mechanisms	211
Sixteen Latch, Toggle, and Trigger Devices	213
Six Snap-Action Mechanisms	215
Eight Snap-Action Devices	217
Applications of the Differential Winch to Control Systems	219
Six Applications for mechanical Power Amplifiers	221
Variable-Speed Belt and Chain Drives	224
Getting in Step With Hybrid Belts	227
Change Center Distance Without Affecting Speed Ratio	231
Motor Mount Pivots for Controlled Tension	231
Bushed Roller Chains and Their Adaptations	232
Six Ingenious Jobs for Roller Chain	234
Six More Jobs for Roller Chain	236
Mechanisms for Reducing Pulsations in Chain Drives	238
Smoother Drive Without Gears	240

CHAPTER 8 GEARED SYSTEMS AND VARIABLE-SPEED MECHANISMS 241

Gears and Gearing	242
Nutating-Plate Drive	243
Cone Drive Needs No Gears or Pulleys	244
Variable-Speed Mechanical Drives	245
Unidirectional Drive	253
More Variable-Speed Drives	254
Variable-Speed Friction Drives	256
Variable-Speed Drives and Transmissions	258
Precision Ball Bearings Replace Gears in Tiny Speed Reducers	260
Multifunction Flywheel Smooths Friction in Tape Cassette Drive	261
Controlled Differential Drives	262
Twin-Motor Planetary Gears Provide Safety Plus Dual-Speed	263
Harmonic-Drive Speed Reducers	263
Flexible Face-Gears Make Efficient High-Reduction Drives	266
Compact Rotary Sequencer	267
Planetary Gear Systems	268
Noncircular Gears	275
Sheet-Metal Gears, Sprockets, Worms, and Ratchets	279
How to Prevent Reverse Rotation	281
Gear-Shift Arrangements	282
Shifting Mechanisms for Gears and Clutches	284
Fine-Focus Adjustments	286
Ratchet-Tooth Speed-Change Drive	287
Twinworm Gear Drive	287
Compliant Gearing for Redundant Torque Drive	289
Lighter, More-Efficient Helicopter Transmissions	290
Worm Gear With Hydrostatic Engagement	290
Straddle Design of Spiral Bevel and Hypoid Gears	292

CHAPTER 9 COUPLING, CLUTCHING, AND BRAKING DEVICES 293

Coupling of Parallel Shafts	294
Novel Linkage Couples Offset Shafts	295
Disk-and-Link Coupling Simplifies Transmissions	296
Interlocking Space-Frames Flex as They Transmit Shaft Torque	297
Off-Center Pins Cancel Misalignment of Shafts	299
Hinged Links and Torsion Bushings Give Drives a Soft Start	300

Universal Joint Relays Power 45° at Constant Speeds	301
Basic Mechanical Clutches	302
Spring-Wrapped Slip Clutches	304
Controlled-Slip Concept Adds New Uses for Spring Clutches	306
Spring Bands Grip Tightly to Drive Overrunning Clutch	307
Slip and Bidirectional Clutches Combine to Control Torque	308
Walking Pressure Plate Delivers Constant Torque	309
Conical-Rotor Motor Provides Instant Clutching or Braking	310
Fast-Reversal Reel Drive	310
Seven Overrunning Clutches	311
Spring-Loaded Pins aid Sprags in One-Way Clutch	312
Roller-Type Clutch	312
One-Way Output From Speed Reducers	313
Springs, Shuttle Pinion, and Sliding Ball Perform in One-Way Drives	314
Details of Overriding Clutches	316
Ten Ways to Apply Overrunning Clutches	318
Applications for Sprag-Type Clutches	320
Small Mechanical Clutches for Precise Service	322
Mechanisms for Station Clutches	324
Twelve Applications for Electromagnetic Clutches and Brakes	326
Trip Roller Clutch	328
Geared Electromechanical Rotary Joint	329
Ten Universal Shaft Couplings	330
Methods for Coupling Rotating Shafts	332
Linkages for Band Clutches and Brakes	336
Special Coupling Mechanisms	337
Link Coupling Mechanisms	338

CHAPTER 10 TORQUE-LIMITING, TENSIONING, AND GOVERNING DEVICES

339

Caliper Brakes Help Maintain Proper Tension in Press Feed	340
Sensors Aid Clutch/Brakes	340
Warning Device Prevents Overloading of Boom	341
Constant Watch on Cable Tension	341
Torque-Limiters Protect Light-Duty Drives	342
Limiters Prevent Overloading	343
Seven Ways to Limit Shaft Rotation	346
Mechanical Systems for Controlling Tension and Speed	348
Drives for Controlling Tension	352
Switch Prevents Overloading of a Hoist	355
Mechanical, Geared, and Cammed Limit Switches	356
Limit Switches in Machinery	358
Automatic Speed Governors	362
Centrifugal, Pneumatic, Hydraulic, and Electric Governors	364
Speed Control Devices for Mechanisms	366
Floating-Pinion Torque Splitter	367

CHAPTER 11 PNEUMATIC AND HYDRAULIC MACHINE AND MECHANISM CONTROL

369

Designs and Operating Principles of Typical Pumps	370
Rotary-Pump Mechanisms	374
Mechanisms Actuated by Pneumatic or Hydraulic Cylinders	376
Foot-Controlled Braking System	378
Linkages Actuate Steering in a Tractor	378
Fifteen Jobs for Pneumatic Power	379
Ten Ways to Use Metal Diaphragms and Capsules	380
Differential Transformer Sensing Devices	382
High-Speed Counters	384
Designing With Permanent Magnets	385

Permanent Magnet Mechanisms	387
Electrically Driven Hammer Mechanisms	390
Thermostatic Mechanisms	392
Temperature-Regulating Mechanisms	396
Photoelectric Controls	398
Liquid Level Indicators and Controllers	400
Instant Muscle With Pyrotechnic Power	402
CHAPTER 12 FASTENING, LATCHING, CLAMPING, AND CHUCKING DEVICES	405
Remotely Controlled Latch	406
Toggle Fastener Inserts, Locks, and Releases Easily	407
Grapple Frees Loads Automatically	407
Quick-Release Lock Pin Has a Ball Detent	408
Automatic Brake Locks Hoist When Driving Torque Ceases	408
Lift-Tong Mechanism Firmly Grips Objects	409
Perpendicular-Force Latch	409
Quick-Release Mechanisms	410
Ring Springs Clamp Platform Elevator Into Position	411
Quick-Acting Clamps for Machines and Fixtures	412
Friction Clamping Devices	414
Detents for Stopping Mechanical Movements	416
Ten Different Splined Connections	418
Fourteen Ways to Fasten Hubs to Shafts	420
Clamping Devices for Accurately Aligning Adjustable Parts	422
Spring-Loaded Chucks and Holding Fixtures	424
Short In-Line Turnbuckle	424
Actuator Exerts Tensile or Compressive Axial Load	425
Gripping System for Mechanical Testing of Composites	426
Passive Capture Joint With Three Degrees of Freedom	427
Probe-and-Socket Fasteners for Robotic Assembly	428
CHAPTER 13 KEY EQUATIONS AND CHARTS FOR DESIGNING MECHANISMS	429
Four-Bar Linkages and Typical Industrial Applications	430
Designing Geared Five-Bar Mechanisms	432
Kinematics of Intermittent Mechanisms—The External Geneva Wheel	436
Kinematics of Intermittent Mechanisms—The Internal Geneva Wheel	439
Equations for Designing Cycloid Mechanisms	442
Designing Crank-and-Rocker Links With Optimum Force Transmission	445
Design Curves and Equations for Gear-Slider Mechanisms	448
Designing Snap-Action Toggles	452
Feeder Mechanisms for Angular Motions	455
Feeder Mechanisms for Curvilinear Motions	456
Roberts' Law Helps to Find Alternate Four-Bar Linkages	459
Ratchet Layout Analyzed	460
Slider-Crank Mechanism	461
CHAPTER 14 NEW DIRECTIONS IN MACHINE DESIGN	463
Software Improvements Expand CAD Capabilities	464
New Processes Expand Choices for Rapid Prototyping	468
Micromachines Open a New Frontier for Machine Design	475
Multilevel Fabrication Permits More Complex and Functional MEMS	478
Miniature Multispeed Transmissions for Small Motors	481
MEMS Chips Become Integrated Microcontrol Systems	482
LIGA: An Alternative Method for Making Microminiature Parts	484